HYDROLOGY

Precipitation

Precipitation data based on Easterling et al. (1995) from gage stations at Lee's Summit, Appleton City, and Clinton indicates an estimated average annual precipitation of 41.0 inches within the South Grand Watershed for the period of 1915-1994 (Figure Hy01). Analysis of individual annual precipitation amounts for the previously mentioned period indicates a slight trend toward increased annual precipitation amounts within the watershed (Figure Hy02a). Mean monthly precipitation data for the period shows that the combined months of April, May, and June receive the most precipitation at 14.38 inches, while the combined months of December, January, and February receive the least amount of precipitation at 5.03 inches. June receives the highest mean precipitation amount at 5.34 inches, while February receives the lowest at 1.60 inches (Figure Hy02b).

United States Geological Survey Gaging Stations

The United States Geological Survey (USGS) currently (2002) has two active surface discharge gaging stations within the South Grand Watershed (Table Hy01 and Figure Hy01) (USGS 2002a and USGS 2002b). Station 06921760 (South Grand River near Clinton, MO)

is located on the South Grand River 5.4 miles downstream from Big Creek. The datum of the gage is 700 ft above mean sea level (msl). Station 06921760 has been recording daily discharge data since July of 1985. Station 06921755 (South Grand River above Clinton, MO) is an auxiliary station to station 06921760. It is located on the South Grand River 2.1 miles downstream from Big Creek and 3.3 miles upstream from Station 06921760. Station 06921755 has been recording real-time river stage since April of 2001. Both stations frequently experience influences from the backwater of Truman Reservoir.

Historical daily discharge and/or peak flow records exist for an additional 12 surface water stations within the watershed with various records available from 1921 to 2000. In addition to the water discharge records, the USGS has collected surface water quality records from 34 locations within the watershed (USGS 2002b).

Daily Mean Discharge Statistics

In an attempt to obtain a comprehensive picture of stream flow within the South Grand Watershed, it is necessary to examine records from multiple gage stations. This is due to the fact that no single station contains both long term and recent flow data. The most recent stream discharge data is available from Station 06921760 (South Grand River near Clinton, MO). However, records from this station only date

back to 1985. On the other hand, the most long term stream discharge data within the watershed is available from Station 06922000 (South Grand River near Brownington, Mo.) Stream discharge was recorded here from 1921 to 1971 but, as is apparent, the most recent data from this gage is over 30 years old. In addition, the site is now inundated by the waters of Truman Reservoir. Data from this station, however, still provides a view of historical and long term trends for the entire watershed which would otherwise be lacking. Daily mean discharge statistics as well other long term hydrologic trends have been analyzed using data from gage stations 06921760 (South Grand River near Clinton, Mo.), station 06922000 (South Grand River near Brownington, Mo), station 06921590 (South Grand R. at Archie, Mo.), and station 06921720 (Big Creek near Blairstown, Mo.). These stations have been chosen for analysis because they provide the most spatially and temporally comprehensive flow datasets for the South Grand Watershed.

The annual daily mean discharge of the South Grand River near Clinton is 1,329 cubic feet per second (cfs) (USGS 2002a). The highest daily mean discharge at this station is 62,300 cfs which occurred on October 1, 1986. The lowest daily mean discharge is 8 cfs which occurred on October 28-November 23, 2000. Table Hy02 lists annual, highest, and lowest daily mean discharges for selected stations within the watershed. Despite the differences in the periods of record, analysis of annual mean daily discharge for analyzed stations show trends in increased discharges at all four stations (Figure Hy03). These trends appear to reflect an increasing trend in annual precipitation amounts. Analysis of historical discharge data for the South Grand River at Brownington, available through the USGS National Water Information System (NWIS) (2000c), reveals that daily mean discharge has historically been lowest during the three month period of November through January and highest during the period of March through May (Figure Hy04). Data for other stations show some variability in this, perhaps in part due to different periods of record.

Flow Duration

Flow duration curves are useful for determining the variability or flashiness of stream flow as well as how the discharge of a stream is sustained over time. These factors are determined by many variables including climate, watershed land cover/land use, soil type, topography, and channel morphology. Daily flow duration curves have been plotted for USGS surface gage stations on the South Grand River at Brownington for the period of record (POR) 1923-1970, Clinton (POR=1986-2000), and Archie, Missouri (POR=1969-1986) as well as for a single station on Big Creek near Blairstown (POR=1960-1974) (Figure Hy05). Slopes of all duration curves are relatively steep at the higher discharges indicating that flood discharges are not sustained for long periods of time. While the curves flatten somewhat in the 10 to 90 percentile range, they are still relatively steep, an indication of high flow variability. The lower ends of the curves for all three stations suggest poorly sustained base flows. South Grand River at Clinton exhibits a slightly more moderately sloping curve than the others. This is possibly due to the fact that this particular gage exists within the Truman Reservoir flood pool and thus is influenced by the reservoir. It is important to note that due to the limited and varied periods of record for all stations, reliable comparison of duration curves between stations is not possible. The high variability of stream flow and poorly sustained base flows in the watershed are in part due to the minimal movement of ground water within the watershed. Groundwater movement is limited by the large amount of shale present in the bedrock of the watershed. In addition, the large amount of agricultural land use as well as

the channelization of some streams within the watershed has had the effect of increasing the rate of runoff and thus limiting sustained flow.

Comparison of duration curves for the time periods of 1923-1946 and 1947-1970 for the South Grand near Brownington show a slight increase in slope in the middle and upper portion of the curve during the latter time period (Figure Hy06). Many factors exert influences on the hydrologic cycle. Analysis of all factors is beyond the scope of this document making it difficult to determine the reason for this change. However, further data collection and analysis of hydrologic data will be important for the continued determination of long term hydrologic trends within the watershed.

10:90 Ratio

The 10:90 ratio is used as an indicator of discharge variability. It is the ratio of the discharge which is equaled or exceeded 90% of the time. It is useful for determining summer carrying capacity in streams as well as interbasin comparisons. The lower the 10:90 ratio the lower the variability of flow. The 10:90 ratio for the South Grand River near Brownington was 1520. This is an extremely high value relative to 10:90 values of drainages of similar size within the state (Skelton 1976). This value is also high compared to the value from the Blackwater River at Bluelick which has a watershed area of similar size but whose 10:90 ration is 600. The value of the South Grand River near Clinton is a much lower value at 69, however this is more than likely due to the effect of Truman Reservoir. Table Hy03 lists 10:90 ratios for additional sites within the South Grand Watershed as well as some neighboring watersheds in Missouri.

Instantaneous Discharge

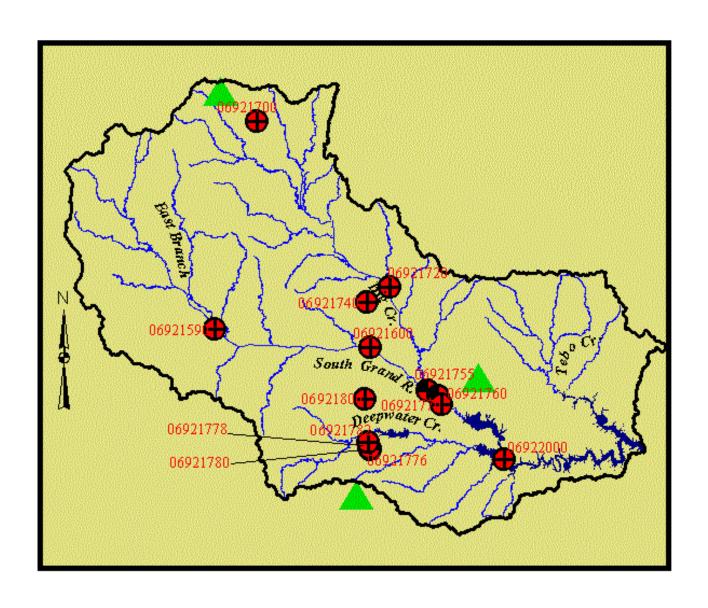
Table Hy02 lists the highest and lowest instantaneous discharge rates that have occurred at select stations within the South Grand Watershed. The highest instantaneous peak flow of 66,000 cfs was recorded in 1986 at the South Grand River near Clinton Station (USGS 2002d). The record instantaneous low flow of 0 cfs was recorded at three of the selected stations including the South Grand River near Brownington in 1928.

7-day Q2, Q10, Q20 Low Flow and Slope Index

Q2, Q10, and Q20 seven day low flows refer to the lowest 7 day discharges that have a recurrence interval, on average, of 2, 10, and 20 years respectively. Some of the issues which low flow statistics help answer include the relative permanency of a stream and thus the streams ability to support aquatic life, the influence of groundwater in a particular watershed, as well as addressing issues related to effluent discharge. The seven day Q2, Q10, and Q20 low flow values for the South Grand River at Urich were 0.1, 0, and 0 cfs, respectively (Skelton 1976). Table Hy04 lists low flow values for additional sites within the South Grand Watershed. Slope indexes for all sites were incalculable due to the seven day Q20 value for selected sites being 0.

Flood Frequency

Magnitudes and frequencies of flooding for the South Grand River near Brownington ranged from 13800 cfs with a frequency of 2 years to 60,900 cfs for a 100 year frequency (Alexander and Wilson 1995). Table Hy05 lists flood frequency estimates for additional selected gage stations within the South Grand Watershed.



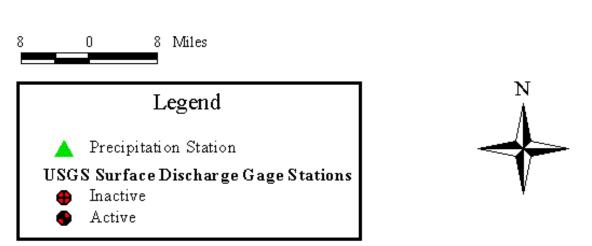
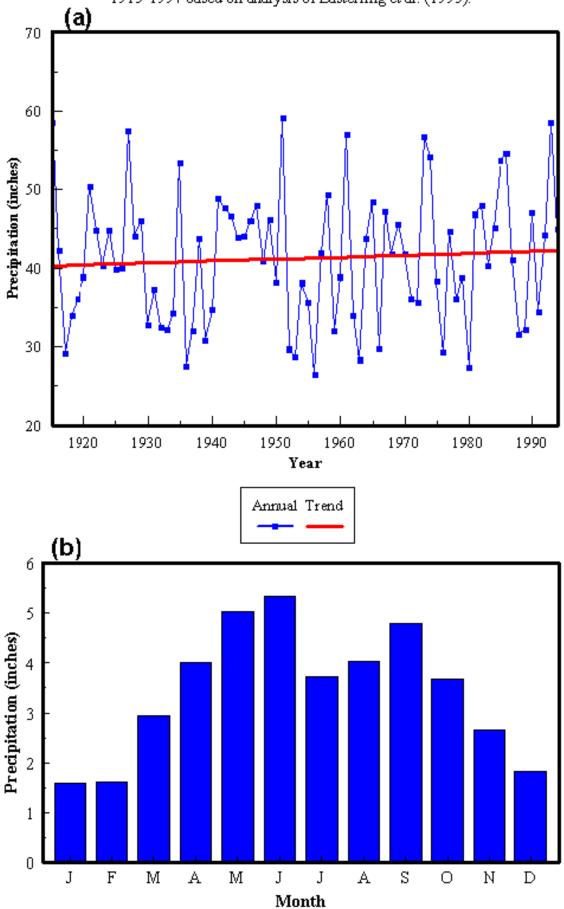


Figure Hy02. (a) Estimated mean annual precipitation amounts and (b) mean monthly precipitation amounts in the South Grand Watershed for years 1915-1994 based on analysis of Easterling et al. (1995).



HY06

Figure Hy03. Annual mean daily discharge and trend (in red) for selected USGS gage stations within the South Grand Watershed (USGS 2002c).

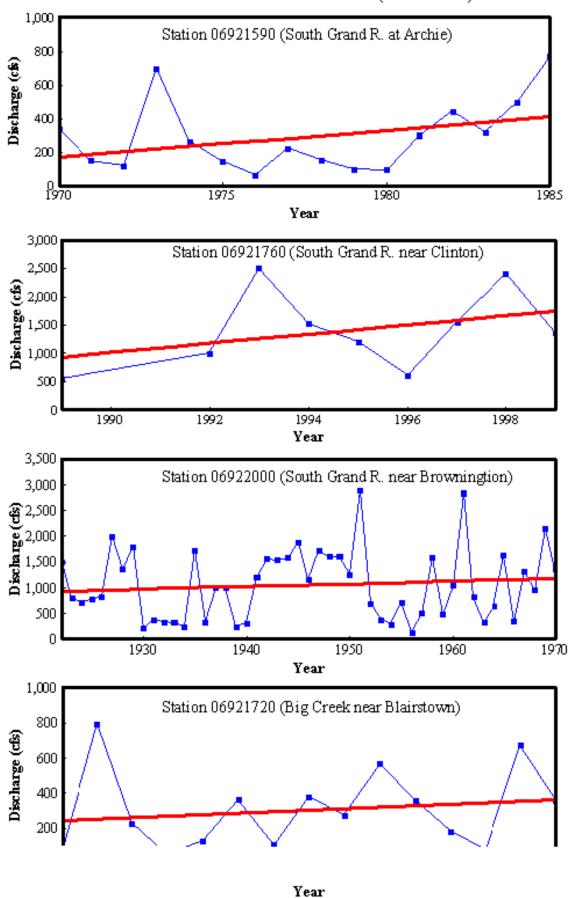


Figure Hy04. Monthly mean daily discharge at selected USGS Gage Stations within the South Grand Watershed (USGS 2000b).

Discharge (cub ic feet per second)

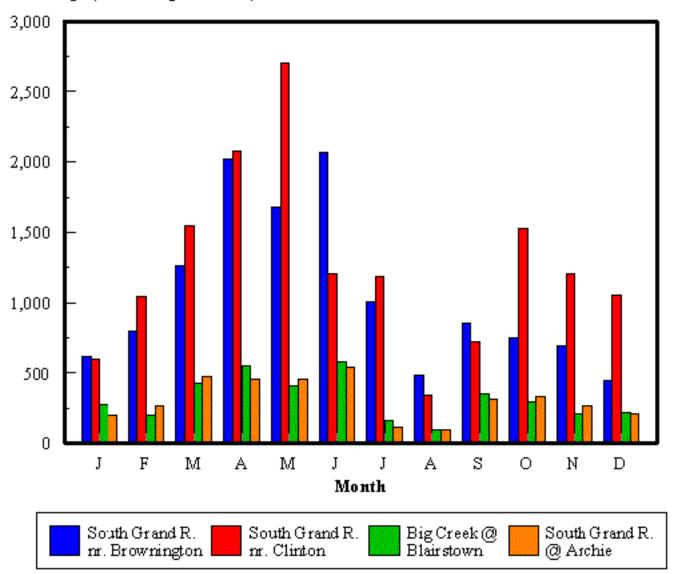


Figure Hy05. Flow duration curves for selected USGS gage stations with varying periods of record within the South Grand River Watershed (USGS 2000c).

Discharge (cubic feet per second)

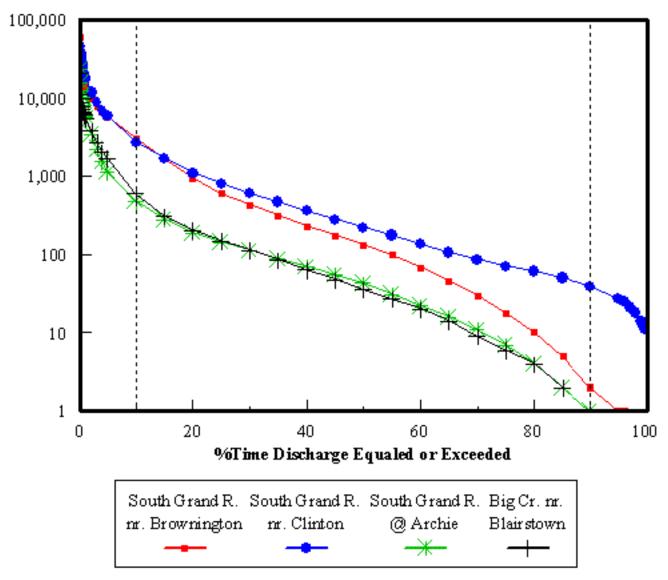


Figure Hy06. Flow duration changes between two time periods (1923-1946 and 1947-1970) at the South Grand River near Brownington.

Discharge (cubic feet per second)

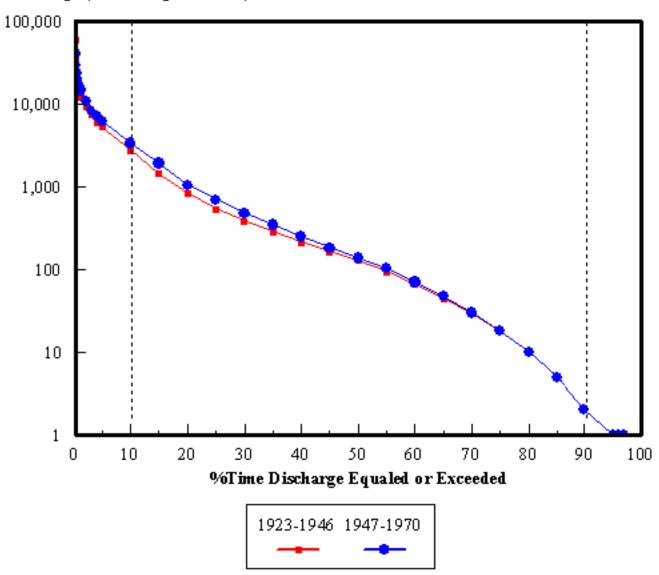


Table Hy01. USGS surface discharge gage stations within the South Grand River Watershed (USGS 2002b). Active stations are in **bold**.

Station	Station Name	Period of	Drainage	Available
		Record	Area	Data
06921590	South Grand River at Archie, Mo	1969-1986	356.00	PDW
06921600	South Grand River at Urich, Mo	1960-1969	670.00	PDW
06921700	West Branch Crawford Cr. near Lee's Summit, Mo	1955-1965	0.80	P
06921720	Big Creek near Blairstown, Mo	1960-1974	414.00	PD
06921740	Brushy Creek near Blairstown, Mo	1960-1975	1.15	PD
06921755	South Grand River above Clinton, Mo	2001-Present	1,260.00	R
06921760	South Grand River near Clinton, Mo	1985-Present	1,270.00	RPD
06921770	South Grand River below Clinton, Mo	1979,		DW
		1994-2000		
06921776	Lake S Outflow near Montrose, Mo	1988-1990		D
06921778	Horn Branch near Germantown, Mo	1988-1990		DW
06921780	Horn Branch Tributary near Montrose, Mo	1985-1990		DW
06921782	Horn Branch near Montrose, Mo	1984-1990		DW
06921800	Granddaddy Creek near Urich, Mo	1958-1979	0.92	P
06922000	South Grand River near Brownington, Mo	1921-1971	1,660.00	PDW

R=Recent/Realtime

P=Peak

D=Daily

W=Water Quality

Table Hy02. Discharge statistics for selected United States Geological Survey Discharge Gage Stations within the South Grand Watershed (USGS 2002c and 2002d).

	Mean	Instant Peak	Max	Min
Station	(cfs)	Flow (cfs)	(cfs)	(cfs)
06921590 South Grand River at	301	24,200	23,400	0*
Archie, Mo.		9/30/86	9/30/86	
06921720 Big Creek near Blairstown, Mo.	319	24,400	20,800	0*
		9/14/61	9/14/61	
06921760 South Grand River near	1,280	66,000	62,300	8*
Clinton, Mo.		10/1/86	10/1/86	
06922000 South Grand River near	1,045	63,900	60,300	0*
Brownington, Mo.		11/19/28	11/19/28	

Mean=Average Daily Discharge

Max=Highest Daily Mean

Min=Lowest Daily Mean

N/A=Not Available

*Multiple Days at This Measurement

Table Hy03. Comparison of 10:90 ratios from the South Grand watershed as well as selected neighboring watersheds within Missouri. (Skelton 1976 and USGS 2002c).

			Drainage	
Station #	Name	Watershed	Area	10:90
06921590	South Grand River at Archie, Mo.	South Grand	356	480
06921720	Big Creek near Blairstown, Mo.	South Grand	414	NC
06921760*	South Grand River near Clinton, Mo.	South Grand	1,270	69
06922000 [@]	South Grand River near Brownington, Mo.	South Grand	1,660	1520
06908000	Blackwater River at Bluelick, Mo.	Blackwater	1,122	600
06907000	Lamine River at Clifton City, Mo.	Lamine	598	204

NC=Not Calculable (90 percentile value =0)

^{*}Gage is located within flood control pool of Truman Reservoir.

[@]Inactivated prior to Truman Reservoir completion.

Table Hy04. Low flow calculations for USGS Surface Discharge stations within the South Grand Watershed (Skelton 1976).

Station #	Station Name	Drainage	Q2	Q10	Q20	Slope
		Area (mi²)				Index
06921580	South Grand River @ Archie	256	0.1	0.0	0.0	NC
06921600	South Grand River @ Urich	670	0.1	0.0	0.0	NC
06921720	Big Creek @ Blairstown	414	0.2	0.0	0.0	NC
06922000	South Grand River nr. Brownington	1,660	1.1	0.0	0.0	NC

NC=Not Calculable (Q20 value=0)

Table Hy05. Two to 100 year flood discharges (cubic feet per second) for selected USGS Gage Stations within the South Grand Watershed (Alexander and Wilson 1995).

	Recurrence Interval (years)					
	(Discharge in cubic feet per second)					
Station	2	5	10	25	50	100
06921590 (South Grand River at Archie, Mo.)	11,700	16,400	19,600	23,700	26,800	30,000
06921720 (Big Creek at Blairstown, Mo.)	7,910	11,100	13,500	16,700	19,300	22,000
06921740 (Brushy Creek near Blairstown, Mo.)	449	713	907	1,170	1,380	1,610
06921800 (Grandaddy Creek near Urich, Mo.)	258	458	624	874	1,090	1,340
06922000 (South Grand River near Brownington, Mo.)	13,800	24,300	32,200	43,100	51,800	60,900